EARTHQUAKES AND VOLCANOES

By
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Librarian of the U. S. Weather Bureau

From a copyrighted photograph by Chester Mullen
ERUPTION OF LASSEN PEAK, CALIFORNIA, OCTOBER, 1915

MENTOR GRAVURES

MESSINA, SICILY—SCENE AFTER THE EARTHQUAKE

SAN FRANCISCO CITY HALL AFTER THE EARTHQUAKE

SEISMOGRAPH

ON THE ROAD TO VESUVIUS, ITALY

RUINS OF ST. PIERRE, MARTINIQUE

THE CRATER OF KILAUEA, HAWAII

THE "molten interior" of the earth has been banished from books on geology, but its place has not yet been satisfactorily filled. Our views concerning things subterranean are distinctly less confident than were those of our grandfathers. We still believe that intense heat prevails far within the globe. Measurements in mines and deep borings show an increase in temperature with descent, which, while it varies greatly from place to place, amounts on an average to about one degree Fahrenheit for each 50 or 60 feet. We also believe that the material at the depth of even a few miles, regardless of its temperature, must be mashed by the enormous weight of the overlying rocks into something like a thick liquid, which flows under strain instead of breaking or crumbling. But this is not quite the same thing as a "molten interior." Most substances expand when melting; in other words, they diminish in density. By several methods, agreeing well in their results, the earth as a whole has been weighed, and its average density is found to be about 5.5 times as great as that of water. Now the average

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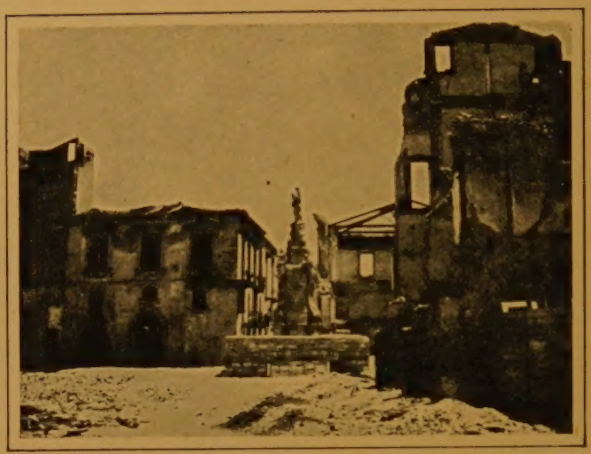
density of the rocks at the earth's surface is only about 2.8 times that of water. In other words, the material in the core of the earth, instead of being lighter than the surface material, as it should be if it is the same in composition but in a melted state, is actually very much denser.



MESSINA AFTER THE EARTHQUAKE
The statue in the center remained uninjured by the shock

Again, the interior of the earth must be extremely rigid. Otherwise, the same pull of the moon and the sun that produces the tides of the ocean would cause great distortions in the shape of the whole globe. Tides in the earth's crust—known as "earth tides"—have, indeed, been observed and measured, but they are so small as to indicate that the average stiffness of our globe is at least equal to that of steel. Lastly, the vibrations due to earthquakes—of which we shall have more to say—travel through the earth in such a way as to give strong support to the belief that the interior is not only very dense, but also a solid, rather than a true liquid or gas. When all is said and done, however, this subject remains enigmatical, because we do not know how matter behaves under the stupendous pressure to which the interior of the earth is subjected.

The Earth's Crust

Concerning the earth's crust we have more positive knowledge. Its history is written in unmistakable language. Strata, the structure and contents of which prove them to have been originally horizontal sheets of sediment deposited at the bottom of the ocean, are now found at all elevations, up to the tops of high mountains, and are warped into folds and creases like the wrinkles in the skin of a dried apple. These deformations of the crust did not all occur in the remote past. Within historic times marked changes of level have occurred in various parts of the world. These changes are especially easy to observe along coastlines, where beaches have been conspicuously raised or lowered within a few centuries.

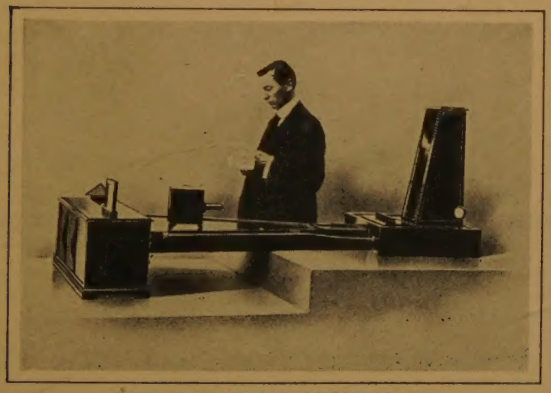
Apart from a general shrinking of the crust that appears to have been in progress from early ages, local oscillations of the surfaces are constantly produced by such disturbing factors as the tides, the transportation of material under the effects of water and wind, falls of rain and snow, and so forth. An increase in the surface load at one place on the earth causes a depression of the crust, and this is likely to be compensated by an elevation somewhere else. Some of the agencies that produce these movements are very gradual in their action; others are abrupt. The study of

earthquakes has revealed the fact that even fluctuations in atmospheric pressure are capable of producing readjustments of level in the earth's crust.

Below a depth of fifteen miles or less the rocks are probably so tightly compressed that, though they yield to squeezing, after the manner of clay or putty, they cannot split. The term *zone of rock flowage* describes the part of the earth's interior in which this plastic condition prevails. Above this zone lies the brittle outer shell of the earth, in which the warping processes above described cause the splitting of the rocky crust into blocks of various sizes, some of them hundreds of miles in diameter. This is known as the *zone of fracture*. At the surface itself the rocks are generally, but not everywhere, overspread with a thin layer of soil.

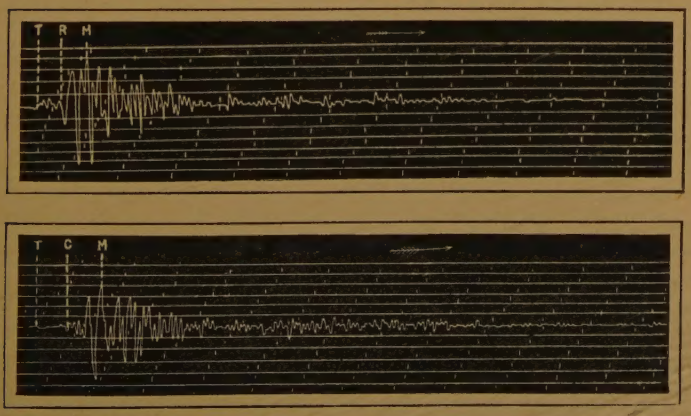
Earthquakes

There are two minor causes of earthquakes that we may quickly dispose of: (1) The subterranean concussions attending volcanic eruptions produce local quakes, not generally of much violence. (2) The collapse of caverns hollowed out in soluble rocks (limestone, etc.) by underground waters causes quakes, also generally local and unimportant.



THE SHAW-MILNE SEISMOGRAPH
Built by J. J. Shaw for the U. S. Weather Bureau

The chief cause of earthquakes, and probably the cause of all those of great magnitude, is the jar given to the earth's crust, either by the sudden formation of the fissures that divide the surface shell into the blocks already mentioned, or by the slipping of adjacent blocks along the walls of fissures previously formed. Such slipping is technically described as *faulting*, and the places where it has occurred are called *faults*. They reveal themselves in many places at the earth's surface in the abrupt interruption of exposed strata, or sometimes by crevasses or terraces in the ground. Since ruptures and faults can occur only within the zone of fracture, the source of an



A SEISMOGRAPH RECORD

earthquake is never more than a few miles beneath the surface.

The breaking of the rock or the slipping of adjacent rock faces upon each other sets up vibrations similar to those produced by the drawing of a violin bow over the strings, and these vibrations are transmitted in all directions through the earth. The part of the earth's surface lying directly over the source, or *focus*, of the disturbance is called the *epicenter* of the earthquake, and here the vibrations are most distinctly felt. It is these vibrations, rather than the mere dislocations of the ground, that do most of the damage in destructive earthquakes.

SCENE IN SAN FRANCISCO AFTER THE EARTHQUAKE AND FIRE, 1906

Except where water-waves and fire add to the destruction, the loss of life that occurs in disastrous earthquakes is almost entirely due to the shaking down of buildings. If people lived everywhere in tents, or if houses were constructed like ships—which are so designed that they may be jolted and tossed about by the waves of the ocean without damage—these now dreaded visitations would do comparatively little bodily injury to humanity. A great deal of attention has been devoted to devising methods of construction and selecting building materials adapted to resist the effects of earthquake shocks, but in the countries most subject to these disturbances (except Japan) the knowledge gained in such investigations has not been generally applied. After the frightful Messina disaster of 1908, in which more than 77,000 people perished, the Japanese authority, Omori, declared that at least 99.8 per cent. of this number were the victims of the faulty construction of buildings. Earthquake damage also depends in part upon the kind of ground on which buildings are erected; those standing on rock are generally less affected than those built on soft earth.

Some Famous Earthquakes

An earthquake that destroyed the greater part of the city of Lisbon in 1755 cost the lives of between 30,000 and 40,000 people. A majority of these people were drowned, after they had fled from the city proper, by a huge wave, sweeping in from the ocean. Such waves are frequently generated by earthquake shocks. Sometimes they have their origin in

earthquakes far out at sea, which are felt on board ships and which may break submarine cables. They inundate nearby coasts, and, like the huge waves produced by hurricanes, are popularly known as "tidal waves," though they have nothing to do with the tide.

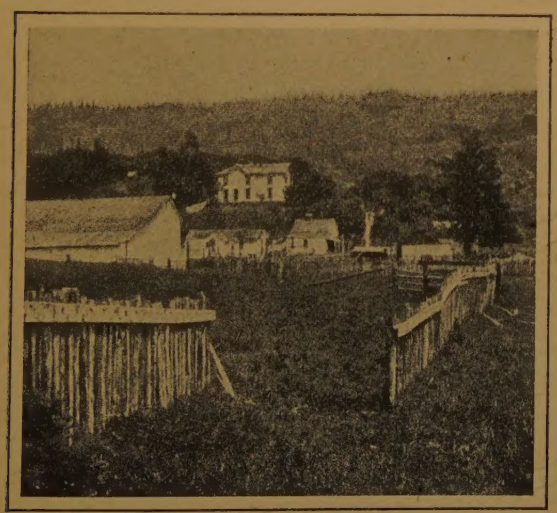
In 1783 numerous towns and villages in Calabria and Sicily were destroyed by an earthquake, with a loss of more than 30,000 lives. This event attracted much attention in scientific circles, and elaborate reports were published upon it.

Probably no other country has suffered so many severe earthquakes as Japan, where the records of modern times show that a destructive shock occurs, on an average, once every two and a half years. In 1891 the densely populated provinces of Mino and Owari, in that empire, were violently shaken, and 7,000 people were killed, while about 17,000 were injured.

The great earthquake that occurred in Assam, India, in 1897, is remarkable for the immense area over which it was destructive, amounting to about 150,000 square miles.

In 1908 the cities of Messina and Reggio, in southern Italy, were completely destroyed by the most disastrous earthquake of which we have any definite record. Official reports place the loss of life at 77,283, but much higher estimates have been published.

The Charleston, S. C., earthquake of 1886, and the San Francisco earthquake of 1906 were the most destructive that have occurred in the United States. In the attendant loss of life these two disasters were insignificant compared with most of the famous earthquakes of history, but in the San Francisco quake the property loss, due chiefly to fire, amounted to more than $200,000,000.



From "The California Earthquake of 1906." Copyright by A. M. Robertson, San Francisco.

EFFECT OF CALIFORNIA EARTHQUAKE

This fence, previously straight and continuous, was broken and parted by the earthquake "fault," the offset being 8½ feet

The New Science of Seismology

Seismology, or earthquake science, is mainly a product of the last thirty years, and its remarkable progress is especially due to the invention of delicate instruments (*seismographs*) which make autographic records of the vibrations set up by earthquake shocks. These instruments record not only the shocks that are perceptible to the senses, but also the far more numerous fainter shocks that are not. The seismograph has shattered our faith in *terra firma*. Our globe is

trembling somewhere most of the time, and a severe shock at any place upon it is recorded by seismographs all over the world. The seismograph is essentially a heavy mass of metal, suspended in such a manner that its inertia prevents it from partaking readily of the motion of the earth when the latter is shaken. A pen or stylus attached to the suspended weight traces a record of the earth's movements on a sheet of paper carried along by clockwork. Complete apparatus of this kind registers vibrations in three directions—north-south, east-west, and up-down.

An earthquake sends out two principal sets of vibrations. One set travels around the earth's surface (*i. e.*, through the crust), while the other takes a "short cut" through the interior of the globe. The latter set is registered first by a distant seismograph, not only because it has not so far to travel, but also because it is propagated at a much greater speed through the material of the earth's core. Moreover, the vibrations that pass through the earth are of two distinct kinds—longitudinal (moving forward and back) and transverse (moving from side to side)—which travel at different speeds and trace waves of different shapes on the record sheet. The difference in the time of arrival of the various kinds of vibrations gives a clue to the distance of the source from the point of observation. These and other characteristics of seismograph tracings (*seismograms*) make it possible to locate an earthquake with considerable accuracy from the records of stations thousands of miles distant.

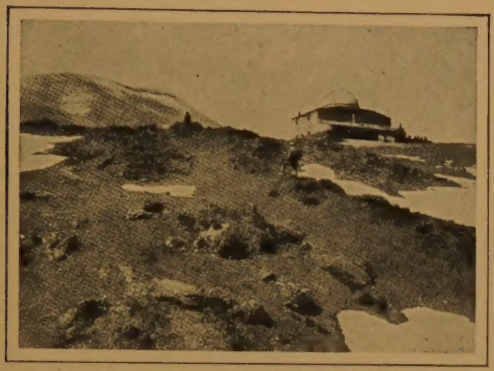
MT. ÆTNA, SICILY—EDGE OF CRATER

Nearly every civilized country now maintains a seismological service, for the sake of coöperating in the worldwide study of earthquakes, and also of determining which regions in each country are most subject to danger from this source. In the United States the "earthquake survey" is conducted by the Weather Bureau.

STROMBOLI, "THE LIGHTHOUSE OF THE MEDITERRANEAN"

Volcanoes

A volcano is an opening in the surface of the earth through which heated matter is ejected. The accumulation of ejected material around the opening usually forms a conical hill or mountain. The opening is known as the *vent* or *chimney*, and the cup-shaped



MT. ÆTNA—THE OBSERVATORY

enlargement at its upper end is called the *crater*. The act of ejecting material is termed an *eruption*, a volcano being described as *active* while an eruption is in progress.

A few volcanoes are constantly active. Among these is Stromboli, in the Mediterranean, which constitutes a natural lighthouse. In most cases, however, there are long periods of repose between eruptions, during which the volcano is said to be *dormant*. If no eruption has occurred within historic times, or if, for any reason, the volcano is assumed to be incapable of further eruption, it is described as *extinct*.

The rocky material expelled by a volcano is called *lava*, if in a molten form, and *ash*, *cinders*, *scoriæ*, etc., if solid. The amount of such material is sometimes enormous. During the eruption of Tambora (or Tomboro), in the Sunda Islands, in 1815, nearly twenty-nine cubic miles are said to have been discharged. A Japanese volcano once ejected so much of the light, spongy material known as *pumice*, that it formed a layer upon the surface of the sea over which it was possible to walk for twenty-three miles.

All violent eruptions include the discharge of an immense volume of steam, forming a huge dust-laden cloud. In many cases this cloud is forked with lightning, and discharges torrents of rain, which, mingling with the dust in the cloud and on the slopes of the volcano, forms a sort of mud-lava. In its hardened form this is called *tuff*.

Contrary to popular belief, there is little real flame connected with a volcanic eruption. The intermittent glow seen over a volcano at night is the reflection of the incandescent lava in the crater upon the overhanging cloud.

The violence of eruptions varies through all grades from quiet outflows of lava to tremendous explosions. The great craters of Kilauea and Mauna Loa, in Hawaii, are examples of the quiet type of volcano. They are characterized by lava lakes, which occasionally well up and overflow. In one discharge Mauna Loa sent forth a stream of lava fifty

THE GLOOMY CRATER WALL OF VESUVIUS

miles long and in some places three miles wide. The most famous of explosive eruptions was that which blew away a great part of the island of Krakatoa, in the Straits of Sunda, in August, 1883. The noise of this explosion was heard 3,000 miles away, and the concussion was so heavy as to break windows at Batavia, nearly 100 miles distant. The dust from the explosion was hurled upward more than seventeen miles, and was carried around the globe by the winds. Its presence in the atmosphere was responsible for remarkable sunset glows all over the world for months after the eruption. The disturbance in the sea produced enormous waves, which drowned more than 36,000 people on neighboring coasts. Another stupendous explosive eruption was that of Mont Pelé,* in the island of Martinique, in May, 1902. This explosion blew away the side of the mountain and sent down the slope a great cloud of hot gases and glowing dust, which annihilated the city of St. Pierre, killing all but two of its 30,000 inhabitants, and destroying most of the shipping in the harbor. The most frightful of all explosive eruptions is said to have been that of Asama, in Japan, in 1783. Bandaisan, in the same country, after remaining dormant for 1,000 years, was the scene of a gigantic eruption in 1888.

SAKURA-JIMA IN ERUPTION
Taken from the quay of Kagoshima, Japan, on January 12, 1914

Vesuvius, on the Bay of Naples, probably the best known of all volcanoes, has had many eruptions, generally of an intermediate type of violence, since the memorable one of A. D. 79, which buried the cities of Herculaneum and Pompeii so completely that for 1,600 years the very site of the latter remained unknown. Excavations have since uncovered about half of Pompeii, but comparatively little progress has been made in disinterring Herculaneum. Apart from its occasional violent outbreaks, Vesuvius is in a state of mild activity most of the time.

Between 300 and 400 volcanoes are at present known to be active. More than half of these are on oceanic islands, while most of the others are close to ocean shores. A remarkable belt of volcanoes nearly encircles the Pacific Ocean. The shores of the Atlantic are almost free from volcanoes.

* The name means "bald mountain." In French this is *la Montagne Pelée* (feminine) or *Mont Pelé* (masculine). The form *Mont Pelée*, widely used by writers of English speech, is impossible French.

MOUNT KATMAI, ALASKA, AFTER THE ERUPTION, JUNE, 1912

Republished from the *National Geographic Magazine*, Washington, D. C.—copyrighted 1917. The National Geographic Society has sent an expedition, under the leadership of Professor Robert F. Griggs, into the Mt. Katmai region, and a very exhaustive analysis will be made by the Society as a contribution to the world's knowledge of this, the greatest of all volcanic areas

COLLECTING GASES FROM THE CRATER OF KILAUEA, HAWAII
These men, in gas masks, have laid a pipe on the lava floor to carry the gases to the collecting tubes and pump

Very few volcanoes have been active within the United States (exclusive of Alaska) within historic times. The latest outbreak was that of Lassen Peak, California, which began a long series of eruptions May 30, 1914.

Mud volcanoes are little hills or mounds of clay, which discharge mud and gases, and sometimes naphtha or petroleum. The "paint-pots" of the Yellowstone Park are examples.

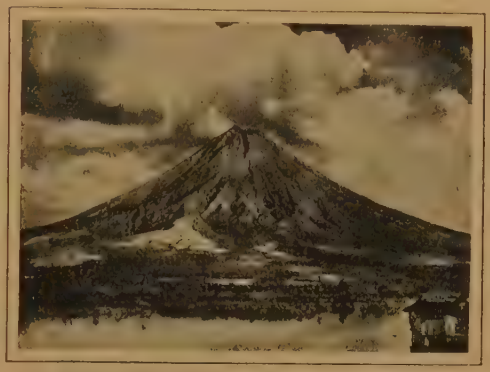
Volcanism and Volcanology

Volcanic activity, in its various phases, is known as *volcanism*, and its investigation has raised a wide range of problems, some of which go back to the remote history of the earth. These, as well as more practical questions, are dealt with by the science of *volcanology*.

Just why volcanoes "erupt" we do not know. The generation of steam appears to have much to do with the process, and this steam is now believed to be formed from water that has always been present in the depths of the earth, rather than from that which has soaked down from the surface.

The average density of lava differs little from that

IN THE CRATER OF KILAUEA



MAYON VOLCANO, PHILIPPINE ISLANDS

of the surface rocks. This fact seems to indicate that such material does not come from a great depth. Its molten condition has been variously explained. As has already been stated, the pressure of the overlying rocks probably prevents the deeper material of the earth from melting, in spite of its high temperature; but if, in the various movements of the crust, this pressure should be relieved at some point, melting would doubtless occur.* The same movements may account for the rise of the lava; a depression of the crust at one place would perhaps force the lava up at another. "Perhaps" and "probably" are words that necessarily recur in any discussion of volcanism.

Volcanology is not so well organized as seismology, but a few observatories have been installed on the slopes of active volcanoes for the purpose of keeping close watch of their phenomena (for example, on Vesuvius and in Hawaii), and daring volcanologists have descended into the craters in order to measure temperatures and collect specimens of volcanic gases. In a few cases fairly accurate predictions have been made of volcanic eruptions.

ERUPTION OF TAAL VOLCANO, PHILIPPINE ISLANDS, JANUARY, 1911

A large reproduction of this picture, with an account of the eruption, will be found in *Mentor* No. 89

The Hawaiian Volcano Observatory, situated close to the crater of Kilauea, issues a weekly bulletin, reporting in detail the state of the Hawaiian volcanoes. Important investigations relating to volcanoes are carried on at the Carnegie Geophysical Laboratory in Washington.

*"Most substances, and probably all of the ordinary rocks, expand in passing from the solid to the liquid condition. . . . For this reason liquefaction is opposed by pressure, and a much higher temperature is necessary to melt a rock subjected to great pressure. The fact that subterranean substances are hot does not, therefore, of itself demonstrate that they are liquid."—*G. K. Gilbert.*

SUPPLEMENTARY READING

EARTHQUAKES *By William H. Hobbs*

EARTHQUAKES IN THE LIGHT OF THE NEW SEISMOLOGY *By Clarence E. Dutton*

VOLCANOES, THEIR STRUCTURE AND SIGNIFICANCE *By T. G. Bonney*

TEXT-BOOK OF GEOLOGY *By L. V. Pirsson and Chas. Schuchert*

GEOLOGY, PHYSICAL AND HISTORICAL *By H. F. Cleland*

PLINY'S LETTERS (Bohn Library) *Edited by F. C. T. Bosanquet*

THE CALIFORNIA EARTHQUAKE OF 1906 *Edited by David Starr Jordan*

SEISMOLOGY *By John Milne*

*** Information concerning the above books may be had on application to the Editor of the Mentor.

Have you read "The Last Days of Pompeii"? If you haven't, get a copy of that fascinating novel at once, and read it in connection with this number of The Mentor. You will find in it a graphic account of the eruption of Vesuvius (in the year 79) that buried the towns of Herculaneum and Pompeii. In the course of time the name of Pompeii passed from the memory of man, and it was not until 1748 that an inspection of an underground aqueduct revealed the fact that under the vineyards and mulberry trees that covered the site there lay the entombed walls of an ancient city.

GEOPHYSICAL LABORATORY, CARNEGIE INSTITUTION, WASHINGTON, D. C. A CENTER OF VOLCANO RESEARCH

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Bulwer's description of the eruption of Vesuvius in "The Last Days of Pompeii" is based on an actual account of the catastrophe written by an eye witness. A young Roman named Pliny (age 18), was nearby and saw the eruption. He told about it in letters that have come down through the years. Pliny's uncle lived close to Pompeii and was lost in the catastrophe. Here is a part of Pliny's story:

There had been noticed for many days before a trembling of the earth, which did not alarm us much, as this is quite an ordinary occurrence in Campania; but it was so particularly violent that night that it not only shook but actually overturned, as it would seem, everything about us. My mother rushed into my chamber, where she found me rising, in order to awaken her. We sat down in the open court of the house, which occupied a small space between the buildings and the sea. Though it was now morning, the light was still exceedingly faint and doubtful; the buildings all around us tottered, there was no remaining without imminent danger; we therefore resolved to quit the town.

A panic-stricken crowd followed us, and pressed on us in dense array to drive us forward. Being at a convenient distance from the houses, we stood still, in the midst of a most dangerous and dreadful scene. The chariots, which we had ordered to be drawn out, were so agitated backwards and forwards, that we could not keep them steady, even by supporting them with large stones. The sea seemed to roll back upon itself, and to be driven from its banks by the convulsive motion of the earth; it is certain at least the shore was considerably enlarged, and several sea animals were left upon it. On the other side, a black and dreadful cloud, broken with rapid, zigzag flashes, revealed behind it variously shaped masses of flame; these last were like sheet-lightning, but much larger.

Soon afterwards, the cloud began to descend, and cover the sea. It had already surrounded and concealed the island of Capreæ and the promontory of Misenum. My mother now besought, urged, even commanded me to make my escape, which, as I was young, I might easily do. But I absolutely refused to leave her, and, taking her by the hand, compelled her to go with me.

The ashes now began to fall upon us, though in no great quantity. I looked back; a dense, dark mist seemed to be following us, spreading itself over the country like a cloud. "Let us turn out of the high road," I said, "while we can still see, for fear that, should we fall in the road, we should be pressed to death in the dark, by the crowds that are following us." Night came upon us—not such as we have when the sky is cloudy, or when there is no moon, but that of a room when it is shut up, and all the lights put out. You might hear the shrieks of women, the screams of children, and the shouts of men; some calling for their children, others for their parents, others for their husbands, and seeking to recognize each other by the voices that replied; one lamenting his own fate, another that of his family; some wishing to die, some lifting their hands to the gods; but the greater part convinced that there were now no gods at all, and that the final endless night of which we have heard had come upon the world.

It now grew rather lighter, which we imagined to be rather the forerunner of an approaching burst of flames than the return of day; however, the fire fell at a distance from us: then again we were immersed in thick darkness, and a heavy shower of ashes rained upon us, which we were obliged every now and then to stand up and shake off, otherwise we should have been crushed and buried in the heap.

At last this dreadful darkness was dissipated by degrees, like a cloud or smoke; the real day returned, and even the sun shone out, though with a lurid light, like when an eclipse is coming on. Every object that presented itself to our eyes seemed changed, being covered deep with ashes as if with snow. We returned to Misenum, where we refreshed ourselves as well as we could, and passed an anxious night between hope and fear; though, indeed, with a much larger share of the latter; for the earthquake still continued, while many frenzied persons ran up and down, heightening their own and their friends' calamities by terrible predictions.

CASCADE MOUNTAIN AND BANFF VILLAGE, ALBERTA

TRAVELERS arriving for the first time in Banff are often surprised to discover a sprightly village beyond the railway station, with numerous shops, tea-rooms, hotels and dwellings occupying its streets. Elsewhere in the Canadian Rockies the diversions have to do solely with the mountains, but in Banff, irrelevantly named for the Scotch birthplace of an early visitor to this region, natural attractions have been skilfully developed by generous sponsors. Clubs, museums, wild animal parks, baths, water trips, drives, trails and sylvan pleasure grounds offer an agreeable choice of amusement to the thousands who pause here each summer and autumn on their way through the Rockies. Everything is at hand for a happy holiday amid a mountain environment unequaled on this side the Atlantic. Above all, there is the inspiration of bulky summits that enclose the village in a formidable stockade.

Cascade Mountain bars one end of the main street, a friendly pile of granite furrowed by a lofty waterfall that lines the face with white. An inclined railway will, it is promised, carry us some day to the top, a mile above the level site of the charming little spa. Cascade's neighbors on the west are Castle Mountain and graceful Mt. Edith, whose treacherous crags frequently lure masters of the pick and rope. The Fairholme Range swings around to the east. On the edge of the village is the towerlike outlook called Tunnel Mountain, and beyond it the riven, snow-crowned rock called Rundle. Behind the town, facing Cascade, is green-mantled Sulphur Mountain. From the road that curves among its woods to the headquarters of the Alpine Club and on to the hot springs and the observatory higher up the steep slopes, we survey the valley of the Bow River and the heights that keep watch above it. The bridge that crosses the river is another vantage-point from which to enjoy an engrossing view of surpassing contrasts and composition. Perhaps the most noted scene in or about Banff is the one that spreads out before the terrace of the Hot Springs Hotel, which occupies a commanding site a mile from the station. Here, between Rundle and Tunnel Mountain, the hasty Bow and the laughing Spray join hands and pass down a flat, broad aisle toward gleaming Mt. Aylmer, 10,365 feet high.

Canoes, boats and launches ply the Bow above the bridge. This excursion is one of the most entrancing in the entire Rocky Mountain tour. Banks are low and grassy, the water clear enough to reflect the green of herbage and tall tree spires, the red and ochre of occasional cliffs, and the gleam of alabaster crowns that appear and disappear as the stream winds in serpent turns through the valley. If the moon lends her lantern these water scenes become miracles of loveliness, too charming to describe.

Most entertaining are the exhibits of live Rocky Mountain animals in the park near the river, and the museum that contains an instructive display of mounted specimens native to the country. The buffalo corrals are visited on the way to Lake Minnewanka, which is nine miles from Banff by road, and is noted for its rock scenery and sportive trout. One may drive or walk to Sun Dance Canyon of aboriginal story. Amusing hours are spent at the Government baths on the road to the Canyon. Most rewarding of all recreations in the neighborhood is a saddle trip with a genial and experienced guide to the foot of some giant monolith, or to distant fields where the Rocky Mountain sheep and goat, the grizzly and the elk haunt the wild places.

PREPARED BY THE EDITORIAL STAFF OF THE MENTOR ASSOCIATION
ILLUSTRATION FOR THE MENTOR, VOL. 5, No. 16, SERIAL No. 140

WHEN we leave the railway and climb through a deer-haunted forest to Lake Louise, we set face toward a community of massive peaks, ice-fed waters and alpine gardens which Switzerland cannot surpass. What the Banff country lacks in solemnity is here in double measure. For form and height and the depth of snow mantles, the group of peaks that enclose the three Lakes in the Clouds are not to be compared with those that stand above the lower reaches of the Bow. Here is illustrious beauty in extravagant phase, "the real beauty that is always too sudden for mortal eyes and brings pain with its comfort." In the Alps," wrote Rupert Brooke, "you are always in sight of a civilization which has nestled for ages at the feet of those high places. They stand, enrobed with worship and grandeur by contrast with the lives of men. These unmemoried heights (of the Rockies) are inhuman—or rather, irrelevant to humanity. No recorded Hannibal has struggled across them; their shadow lies on no remembered literature."

The chill magnificence, the austerity of the panoramas about Lake Louise bring a sense of oppression, a realization of life's trivialities and the futility of human hopes and strife.

Paths accessible to man and horse radiate from the little hotel settlement on the edge of the limpid mile-long pool, now a peacock hue, now "a milky emerald," now "the opal distillation of all the buds of all the spring." On a clear summer morning leave the chalet, the green lawns and the poppy beds and ramble by the lakeside to the base of Victoria's icy terrace. Look up to the stratified dome of Lefroy, to the dim slopes of Whyte and Niblock, to the cone of St. Piran and the mound of the Beehive. Fairview and Temple (11,626 feet) come into the picture, while, behind the immediate wall of the lake, loom Aberdeen, Deltaform and Biddle—names written large in the chronicles of daring mountaineers. Heights near the lake are often attempted by amateurs. From the trail leading a thousand feet upward from Lake Louise (6,000 feet) to Mirror Lake and Lake Agnes (which complete the trio of the Lakes in the Clouds), and from the top of St. Piran and the Beehive, the views are uncommonly fine, and the path not too difficult for pedestrians stout of limb and heart. Everywhere are wondrous vistas of steep forest pitches outlined in acute angles against flanks of snow, of lakes that shine like silver discs far down mountain gullies, of upreared prows and brusque white shoulders swathed in drifting clouds.

Particularly recommended is the ascent of Mt. Victoria (11,355 feet) by way of Abbott Pass. Victoria glacier, which forms so effective a closure at the end of the lake, is three miles wide and may be traversed with a guide. Beyond Lake Louise and lying below Mt. Hungabee is Paradise Valley, where the prospect approaches "a climax of grandeur," where meadows of wild flowers watered by snow streams defy the encroachment of towering crag and col, and broad cascades foam down stairways of rock.

Every afternoon during the tourist season stages leave the hotel for a nine-mile drive to the haunting Valley of the Ten Peaks on the other side of Mt. Temple. At the base of ten spires that rise sharply to the sky lies Moraine Lake, in a remarkable glacial basin a windy, melancholy retreat, treeless, and of a forlorn beauty that fascinates and repels. Above it in a rocky fastness is Consolation Lake, fair, and full of fish. Walter Dwight Wilcox, F. R. G. S., discoverer of the Valley of the Ten Peaks, names Lakes Louise and Moraine, with Wenkchemna Lake in a neighboring valley, and O'Hara and McArthur on the Divide, as "a galaxy of mountain tarns unequaled in any part of the world."

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THE master peaks that soar above the track of the Kicking Horse are the fantastic pile called Cathedral Mountain and the immense abutment named Mt. Stephen. Opposite are Mts. Burgess and Field, not so high, yet stately enough, with heads lifted a mile above the pebbly flats of the river-bed. In the summer one can walk some distance through the gorge, stepping from one small island to another and spanning lazy rivulets. But above the town, where the Yoho River comes in, and a few miles below at the rapids, the stream verifies its mischievous, unruly name in picturesque fashion. It is related, however, that the ungovernable habits of the river had nothing to do with its naming. Sir James Hector, one of the explorers of the Canadian Pacific route on the Palliser expedition, received a kick from a horse while in camp which laid him unconscious. His Indians, thinking him dead, dug a grave and would have buried him but for the fortunate chance that before the undertaking was accomplished he recovered his senses. He afterwards made a pilgrimage of curiosity to the place that had been prepared for him, and, continuing to explore the valley, found the pass over which the railway now runs. In token of the accident that brought good out of evil, he baptized the river the "Kicking Horse."

The traveler that stops off at Field generally does so with two objectives in view. Even if the stay is to be no longer than a few hours' duration, plans are made to take the drive through the Yoho River gorge and to Emerald Lake. If ponies are commanded for the excursion, a circular tour is arranged to include both trips, the ridge between valley and lake being crossed by trail. The source of the Yoho River is about a dozen miles from Field. Proceeding up the Kicking Horse Valley, stunning views of Mt. Stephen and its glacier are obtained from the north river-bank. High on its ledges cling the chutes and huts of a galena mine, to which men climb each day from the village. At the joining of the boisterous Yoho with the Kicking Horse we look back upon a long-remembered picture of Mt. Stephen, beyond the towers, arches, casements and fallen columns of Cathedral Mountain.

The chisels of the builders have bitten deep into the cliff above Yoho gorge to make a path accessible to vehicles. It is an exciting rise, up precarious steeps and spirals, with the enveloping sound of the restless river coming from far below. In confusing contrast are the fields of forget-me-nots, daisies, violets and crimson paint-brush that intervene between the canyon drive and an alley of tall evergreens. This is another of those floral surprises that so frequently enliven remote places in the Rockies.

The enchantress of the Yoho region is the proud cascade that springs from the forefoot of Daly glacier and drops 1,100 feet over the face of ruddy cliffs to the valley. Its Indian discoverers exclaimed, "It is wonderful!"—Tak'-ak-kaw—and by this expressive phrase the highest cataract in Canada is still designated.

A tent camp on a flat opposite the plunging, swaying, rainbow-ridden waterfall receives guests during the summer. Expeditions continue from this point to the glacial source of the Yoho, to Twin Falls and to other wonder-places at the head of the valley. Trails lead around Emerald Lake, and cross Burgess Pass, from which a sea of gleaming peaks unrolls.

The road to Emerald Lake from Field passes near Kicking Horse rapids and files for seven miles between straight, dark trees, with a snow-cap closing either end of the avenue. Lodgers in the rustic hospice overlooking the lake in its bowl-like bed have an unstinted view of Burgess and Field, Wapta, Michael, the President and the Vice President, which rear their hoary cones approximately 10,000 feet above sea level. These make a circular wall over 5,000 feet high to shut in the idyllic sheet of water that carries their serene image on its face of mystic green—now jade, now opal-hued, now brilliant emerald shading to the tints of a dragon-fly's wing.

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MALIGNE GORGE—JASPER PARK, CANADIAN ROCKIES

JASPER PARK is a vast gallery of natural masterpieces, reserved for the people's pleasure. Within its bounds no element of mountain majesty is lacking. Most curious is the turbulent behavior of the Maligne (Mă-leen) River, whose eccentric gorge, accessible by wagon-road, is nine miles from Jasper station, near which there is tourist accommodation. "The river of strange habits" has taken its rise far to the south below Mt. Brazeau, has passed beneath the Ramparts and entered Maligne Lake; from Maligne Lake it has expanded into Medicine Lake, and contracting again draws near to its end in the Athabasca. Where we come upon it through the forest, the Government has erected a shelter, and two bridges, neither of which is more than a few feet long. Under these insignificant spans, which form advantageous platforms from which to witness its seething, chiseling, resounding descent, the maddened river grinds its way through a barrier suddenly thrown across its course. The display from the upper foot-bridge is impressive for evidences of water's centrifugal force. Rocks are hollowed like a dead stump, are turned out like basins from a potter's wheel, are grooved and gored with circular markings. Down this extraordinary terrace the water dashes, swirling in and out of tiny coves, leaping from ledge to ledge in the narrowing channel, burrowing always deeper in the rock. At the lower bridge the river is compressed through a spout from which it emits a roaring straight-hung gush of spray that gouges out a cauldron far below. Deeper grows the flume as the fall gains force and weight, and closer draw the walls, until one standing on the brink can no longer see the frantic plunging, but only hear the clangor that ascends 130 feet or more from the depths of the gloomy fissure. Boulders rolled over the edge carom from side to side for seconds before they reach the bed.

"Enticed by the wizardry of the stream which before our eyes has sunk into a granite hill, we pursue the inclined cleft down a grassy slope, and there, suddenly readjusting the focus of our vision and of our mental range, look as from a great stadium upon a reach of infinite breadth and height that embraces the Valley of the Athabasca and the grandees above the Divide. An unparalleled transition, which leaves a permanent mark on the memory."

Medicine Lake is twenty miles from Jasper station by trail. Aside from its park-like surroundings, it has a peculiar interest for the traveler because the Maligne River here disappears through a subterranean channel, the actual outlet being unknown.

Maligne Lake, already mentioned as a mountain gem of incomparable beauty, is bordered by a range whose glaciers reach almost to the water. The lake was discovered in 1908 by six men and women who traveled north from Lake Louise to find an unmapped region reported by Indians, and were rewarded by coming upon "the finest view any of them had ever beheld in the Rockies," when they saw the lake sparkling at the base of the jagged Opal Mountains, clad in their variegated raiment of rock and ice.

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MT. ROBSON—THE MONARCH OF THE CANADIAN ROCKIES

BEYOND Yellowhead Pass, named for a tawny-haired trapper of fur-trading days, is Robson-land, which constitutes another sumptuous Government park. Mt. Robson, "a giant among giants, immeasurably supreme," has a base area thirty-six square miles in extent. Its summit is 10,000 feet above the Fraser Valley, and the valley is about a third as high above the sea. Fortunate is the observer who discovers the Titan of the northern cordillera in full stature, or bound only with scarfs of filmy vapor about its brow. For days at a time it is curtained by impenetrable clouds. This community of peaks is peculiarly a meeting-place of storms, and many who cross the Divide to see the glories hereabout return without even a glimpse of Robson and its cohorts.

At Mt. Robson station, campers and mountaineers going into the park leave the train and begin the ascent of the seventeen-mile trail that leads to Robson Pass. "A parkland between Robson and Mt. Whitehorn (11,101 feet) extends for five miles through the river valley beyond Lake Helena. Bedecked with forty falls which cast their sheen upon the mural precipices in leaping lines of white, this part of the upward journey is a magnificent prelude to Berg Lake, the source of the Grand Fork, and to views from the pass of Mt. Resplendent, Whitehorn, the Dome, Helmet, Rearguard, Lynx, Mumm, Kain and other summits of wildest splendor." The tranquillity of Berg Lake, at the foot of Robson, is frequently disturbed by falling shafts of ice, which glide down the face of the tumbling glacier and cause the water to surge in waves against sheer granite sides.

The chief cataract of the park is Emperor Falls, formed by the descent of the Grand Fork in full volume over the brink of a high ledge.

All the distinctive features of the Canadian Rockies are found in this superb domain—lakes that mirror walls of green and white, abrupt rock formations, hurrying rivers, peaceful flat-lands enameled with flowers of every hue, and, gleaming above them, stupendous fortresses armored with ice, pinnacled by soaring shafts of snow, canopied by the sky. But the reigning miracle of the reserve is Robson, "overwhelming in its sudden upleap and inaccessibility."

"The only northern rival of Mt. Robson in beauty and grandeur" is viewed a hundred miles to the northwest. In 1914, an American woman, accompanied by a famous guide who already had the difficult summit of Robson to his credit, explored the trackless wastes beyond the park and brought back geographical data concerning a big mountain, yet officially unnamed, whose altitude is estimated at 11,000 feet.

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OTO BY BRYON HARMON, BANFF MT. ASSINIBOINE. THE MATTERHORN OF THE CANADIAN ROCKIES

UNTIL conquered in 1901, Mt. Assiniboine (As-sin′-i-boyn), which rises in a transcendent sharp peak twenty miles south of Banff, "had repelled more assaults than any other peak in the Canadian Rockies." Its sides were first attempted in 1899, but brittle, slippery rock, ice-hard snow and brusque pinnacles held off successful attack. Outram and two guides gained the summit by the exercise of daring and good judgment, aided by ideal climbing weather. The apex of the mountain, aptly called the "Matterhorn of the Rockies," is two miles above sea level. The pastoral character of the country that spreads like a flowery carpet about its base adds especial glamor to the height of the noble peak.

Most difficult, and one of the last to be ascended of all the northern Rockies is Robson, whose crest was first attained in 1909. In that year Rev. George Kinney and Donald Phillips fought their way against snow and wind, and with fifty-pound packs on their backs scaled vertical cliffs and traversed crevasse and serac to reach the summit. "For hours," writes Kinney, "we steadily climbed those dreadful slopes. So fearfully steep were they that we climbed for hundreds of feet where, standing erect in our foot-holds, the surface of the slopes was not more than a foot and a half from our faces, while the average angle must have been over sixty degrees. There were no places where we could rest. . . . The clouds were a blessing in a way, for they shut out the view of the dreadful depths below. . . . When within five hundred feet of the top, we encountered a number of cliffs covered with over-hanging masses of snow that were almost impossible to negotiate . . . and fought our way up the last cliff only to find an almost insurmountable difficulty. The prevailing winds being from the west and south, snow driven by the fierce gales had built out against the wind in fantastic masses of crystal, forming huge cornices all along the crest of the peak. . . . We finally floundered through these treacherous masses and stood, at last, on the very summit of Mt. Robson."

The "big climbs" of the Ranges generally resolve themselves into two classes, those notable for their obstacles of ice and snow, and those whose chief challenge is their "rock work." Robson combines both perils in fearsome measure. The crags of Pinnacle Mountain and other units of the group above Lake Louise are accessible only to experts skilled in negotiating sheer slopes of "rotten rock." Assiniboine denies its white steeps to mountaineers except in nearly perfect weather conditions. Sir Donald, in the Selkirks, presents alluring difficulties to hardy rock climbers. Sir Sandford, a still higher and more northerly peak in the same system, tempts adventurers by reason of its inaccessibility and treacherous snows. The Purcell Range yields exciting crag adventures among the heights above Invermere.

In his volume on the Canadian Rockies, Sir James Outram gives a list of first ascents of forty peaks whose altitude is above 10,000 feet. He himself first climbed to the apex of Mt. Columbia, second highest of the Canadian peaks, and chieftain of the rarely visited group which "contains the greatest aggregate of mighty peaks and sweeping ice-fields in the Canadian Rockies," and comprises an area of two hundred square miles between the two rail routes.

Mt. Stephen, above Field, was the first peak of the Range to be climbed, a member of the Dominion Land Survey having reached the top in 1887. A book by Green and Swanzy, two clergymen, members of the American Alpine Club, who explored the Selkirks in 1888, "had much to do with the first awakening of interest in the American Switzerland." Two years later, two Swiss climbers reached the summit of Sir Donald. Then followed the notable explorations of Wilcox and Allen in the neighborhood of the Divide, "which opened up a vast area of new ground, and introduced the rope and ice-axe with conspicuous success." Other pioneer climbers who made history in this region were Prof. Charles Fay, Norman Collie and Hugh Stutfield, Jean Habel, the German alpinist, Edward Whymper and H. C. Parker. In 1912 Palmer and Holway reached the baffling crest of Sir Sandford. Mt. Cavell, south of Jasper station, was conquered without guides by Gilmour and Holway in 1915. Weather conditions in the Selkirks are so frequently and persistently hampering that great difficulty is experienced in exploring new territory.

Comparing the Rockies of Canada with those that continue across the line into the United States, and with the Alps, Outram says, "Though the highest individual peaks and greatest mean elevations are found south of the Canadian border, the general character becomes more abrupt and rugged, more alpine in its vast areas of glacier and striking grandeur of pinnacle and precipice, till, in the region between the 50th and 53rd parallels, the only real counterpart of the Alps is found. . . . Added to all, in Canada there still exists that chiefest charm of novelty and adventure, the thrill of climbing virgin peaks, of traversing untrodden valleys, of viewing regions never seen before by human eyes."

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